Using Some of Quality Techniques in Supply Chain Management to Improve the Production Processes

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***Abstract*- The research tackled the problem of lowing the level of Supply chain quality in the productive line for the manufacture of cylindrical and conical filters at Al-Zawraa General Company and the line of auto assembly, Saiba (Tiba) type in the General Company for automotive industry. as well as non-adoption of modern and developing techniques in the field of quality which led to the increase in the number of defective products in addition to the diversity of defects types. The target of research is to reveal the impact of using (Six Sigma) Technique and (Taguchi) function in the improving of production processes in the abovementioned companies; as well as to reveal the differences in the level of improving of production process, and determining the reasons that leading for deviations in production processes which participate in reducing the level of quality and develop appropriate solutions; after determining the current level of quality for both companies and the mechanisms used in measurement and quality control for both companies. The research reached a number of results, the most important of which is the possibility of applying Six Sigma in the two lines of the subject of research and giving good results for improvement. The fourth level of Sigma was reached after the third level and the number of defects was reduced; as well as research reached to determine the possibility of applying the Taguchi function - design experiments in the assembly line, Because of the lack of study able levels. Therefore, the loss function of Taguchi was applied instead. The most important conclusion was that the use of Six Sigma in the manufacturing and assembly lines is more efficient than Taguchi, and the lack of documentation of data for inspection by the quality control department of the two research groups, To identify the causes and problems that are repeated, analyzed and work on the treatment, and the methods of work that are applied both in the manufacturing line or in the assembly line is traditional not keeping pace with developments in the production and manufacturing processes, and the weak of performance of some employees due to lack of training courses and lack of experience and skill. The research produced a set of recommendations, the most important of which are: The use of modern technologies for quality and application for improvements, especially Six Sigma, which it is possible to apply in both types of production lines. Establish training courses for the employees to improve the work method and develop it and raise their achievement rates to improve the efficiency of the completion of the work.**

Keywords: *Supply chain management (SCM), Quality Techniques, production processes*

1. Introduction

The methods of (Six Sigma) and (Taguchi) are considering the best modern methods for the amazing improvement for the SCM quality of products and processes. "Motorola" Company considers the first to use this technique to express its quality program, and many international companies such as "General Electric" have proven to save millions of dollars due to the correct application of both technologies. Therefore, the continued use of traditional techniques to measure the quality of production processes cause many problems in processes and therefore defects in products, so that the researcher sought to study the types of modern technology in quality and tried to employ them to serve the processes in the line.

1.1. Research Problem

1. Does the company have an approved technique to measure the quality of its products?

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2. How to choose the appropriate measurement technology to improve the quality level in the production line?

3. Are there differences in the level of improvement of the production process when using different quality techniques (Six Sigma), (Taguchi) in the production line?

4. Are there differences in the level of improvement of the production process when using the same technology (Six Sigma),(Taguchi) in different types of production lines?

5. Do (Six Sigma), (Taguchi) quality techniques contribute to raising the quality of the two companies in question?

1.2. Research Goals

1. Choosing the quality technology that appropriate for the nature of production process in the production line.

2. Determining the production problem and its type and analysis the underlying root causes after the appearance of the last.

3. Finding the appropriate solutions for the production problems that affect on the level of quality and take the necessary actions to tackle them.

4. Reducing the quantity of damaged products and the total defects for the product and raising the level of quality for both companies.

1.3. Research Importance

1. Helping the two companies in raising the level of Products' quality.

2. Improving the production processes for the two companies.

3. Choosing the appropriate technology for the quality which enables the two companies in question to raise the level of the quality of its production processes and its products.

4. Clarifying the importance of choosing the appropriate technology for the type of production line in reducing the defects at each of products and processes.

2. Methodology

2.1 Tools of Research Measuring

Table1. Tools of research measuring in SCM

Source	Details	Equations	Variant	P
[1]	The ratios are used sequentially to measure DPMO	1 - Percentage of defects = number of units containing one or more defects / total number of units produced… 1 2 - Ratio of operations accuracy = 1 - percentage of defects … 2 3 - Defect per unit (DPU) = Number of total defects / number of total produced units …3 4 - Defect per opportunity (DPO) = Number of total defects / number of total produced units x Number of defects types…4 5 – Defects per million opportunity (DPMO)= DPO x 1000000… 5	DPMO	1
[2]	(NTS)(Nominal The Best) this ratio used when the target value is specified but not zero, such as dimensions and weights, the following formula is used (6)	$\boldsymbol{S/N = 10\ log\left[\left(\frac{\bar{X}_i}{S_i}\right)^2 - \frac{1}{n}\right] \ldots..(6)}$	TAGUCHI	2
	(STB)(Smaller The Better) it is used when reducing the functional characteristics as in the surface defects, and it contains only the maximum specifications, above this value; the product does not achieve to the customer	$\boldsymbol{S/N = -10\ log(\frac{1}{n}\sum y_i^2) \ldots..(7)}$		

	the functions wanted to be performed and therefore the typical target value is equal to zero, and is given as follow:			
	(LTB)(Larger The Better) It is used when aggrandize features and functional characteristics, such as the strength of the cutting of the iron blades, the strength of the weld and the resistance of an object, and is given as follow:	$S/N = -10\, log(\frac{1}{n}\sum\frac{1}{{y_i}^2})$ ..... (8)		
Where: σ: standard deviation, y_i: samples y_n,… y_3,y_2,y_1				

SIX SIGMA: Ref. [3] pointed out that the basis of the Six Sigma lies in understanding the negative effects of the variations and changes that occur in the manufacturing processes, and the company however do its efforts to success this entrance; but the improvement processes will not be achieved and succeed unless they specialize enough resources for their financial, material and human administration. The main objective of Six Sigma is to reduce the defects and discrepancies to (3.4) defects per million chances [4] as shown in Table (2):

Table 2. Defects per one million opportunities (DPMO

Level of Sigma	Defects per one million opportunity (DPMO)	Percentage of Accuracy
1	697700	30.23
2	308700	69.13
3	66810	93.32
4	6210	99.379
5	233	99.9767
6	3.4	99.99966

’Improving the performance of six sigma: A case study of the six sigma process of Ford Motor company’ A thesis submitted to the University of Bedfordshire, in partial fulfillment of the requirements for the degree of DBA, P40 [5]. It can be defined as a management philosophy focused on Improving the efficiency and effectiveness of companies [6] or it is a method applied in various industries to solve problems and improve the performance of products, services and processes, reducing costs and defects to reach 3.4 defects per million opportunity [7].

Sample DMAIC

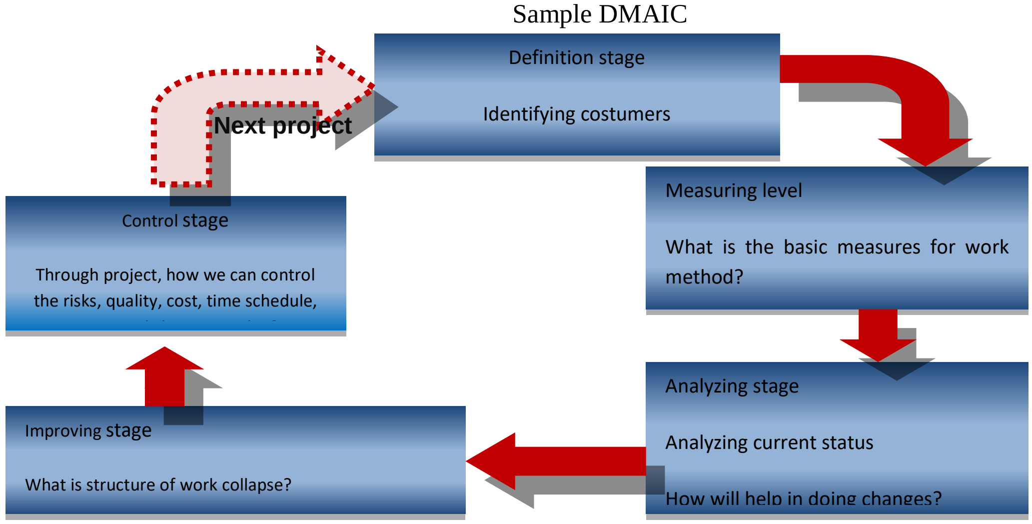


Figure1. Level of implementing approach of DMAIC

[1]: The Six Sigma Handbook - Revised and Expanded (A Complete Guide for Green Belts, Black

Belts, and Managers at All Stages), the United States of America, The McGraw-HIll Companies, Inc., P239

Taguchi does not agree with traditional ideas of quality, which usually allow for discrepancies as long as they are within the permissible limits. He emphasized that any deviation from the target value is a loss even if the latter is within the limits of the established specifications of control and permitted [2] and that one of the most important contributions is signal / noise ratios, which have many types are: [7], [8].The design of experiments is a series of techniques that include the identification and control of factors or variables that have a potential impact on the performance and reliability of the products or processes of production and therefore on the outputs, the selection of two or more values (specific stages) of the variables and operation of the process at these stages. It can be said that the matrix of stability contains two basic elements, Factors and Stages. The number of tests is determined by the number of each, if there are three factors and two stages; the matrix can be L4, L8, L12, L16, and L32, so L4 is chosen so that the main goal is to conduct as few tests as possible, therefore format of the matrix will be as follow:

Table 3. Matrix of Tests for Three Factors and Two Stages

	FACTORS		
TRIAL	A	B	C
1	1	1	1
2	1	2	2
3	2	1	2
4	2	2	1

Prepared by researcher depending on Minitab program

3. Application Side

The application of Six Sigma (DMAIC model) in the manufacturing line / factory of air filters - Al Zawra' General Company [1], [3]. The filter consists of two separate parts, the first cylindrical and the other conical. The process of producing the filter product consists of several manufacturing stages: Cutting belt clips, cut the covers, cast the Gasket, cracking paper, and filter waxing. The process of belt clips cutting will be taken as a sample and applying the level of definition on it, as shown below:

1. First Stage:

Definition: The project definition stage includes identification and definition of the problem and identification of the tools used for improvement. Where 187 work groups were entered starting from 19/01/2016 till 01-08-2017 (obtained from the factory records). The Pareto chart was used as a tool to identify the types of defects and their repetitions and identify the few affecting problems (few affecting as named by scientist Pareto). The type and number of line, working group, date of examination, name of the product, number of filters produced (size of sample), type of defect and number of defects.

The data shown in Fig. 2 were used to draw the Pareto diagram, which shows the columns in blue indicating the refers to relativity repetitions of the defects types and the red line refers to cumulative relative frequency of the defects. The x-axis represents the sequence of defects and the y-axis represents the relative frequency of defects. Through the diagram shown in Figure 3, we observe the increase the frequency of the first defect form the frequency of the second one, which gives the impression of the process-based operator that the first defect should be treated before starting in the treatment of the second defect.

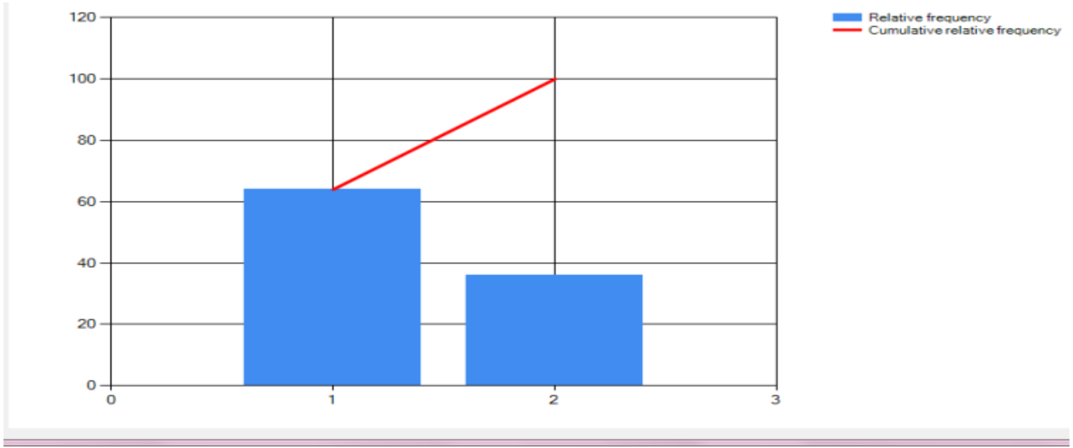


Figure2. Pareto of belt clips – before improvement

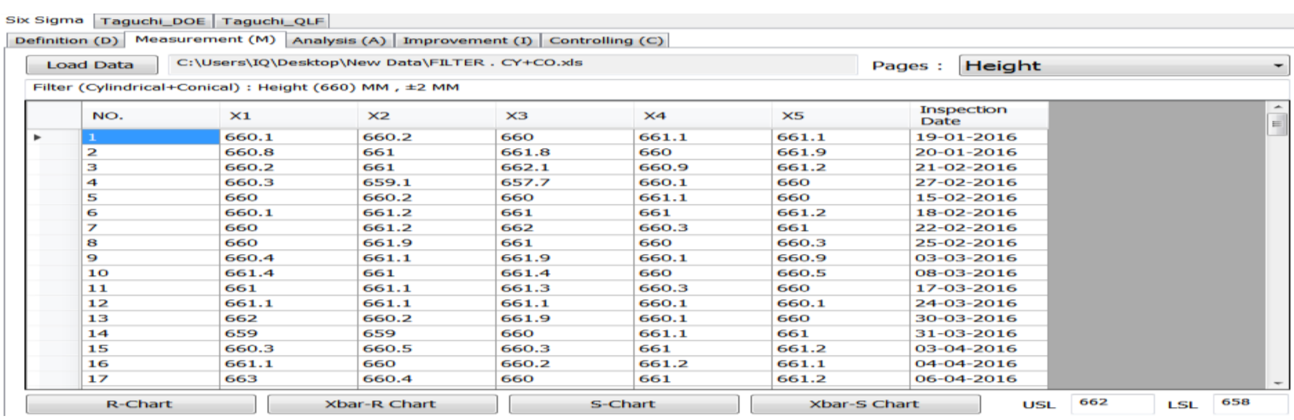
Table (3) shows the number and type of defects in the belt clips. Two types of defects can be observed:

1. Welding inaccuracy, which had a total frequency equal to 498 times, relative frequency and relative cumulative of 64.01%

2. The perimeter of the clamp isn't equal, with frequencies equal to 280 times and a relative frequency equal to 35.99%.

3. Results

Data were analyzed by using statistical methods such as average and range plates, samples (products) out of the limits of control and carrying out the final process of exclusion in SCM. At this stage, the medium-range plate and the medium-standard deviation plate are used to determine the samples that out of the control limits of these plates and then calculate the ratio of Cp and Cpk and the SIGMA level of the company, after the stability of the process for all dimensions of filter which are the high of filter, Gasket thickness, Small diameter, large diameter and weight, the measurement phase will be applied on the first as a sample. At this stage, the data shown in Fig. 4 were used to determine the sample number, first view, second view, third view, fourth view, fifth view and test date.



NO.	X1	X2	X3	X4	X5	Inspection Date
1	660.1	660.2	660	661.1	661.1	19-01-2016
2	660.8	661	661.8	660	661.9	20-01-2016
3	660.2	661	662.1	660.9	661.2	21-02-2016
4	660.3	659.1	657.7	660.1	660	27-02-2016
5	660	660.2	660	661.1	660	15-02-2016
6	660.1	661.2	661	661	661.2	18-02-2016
7	660	661.2	662	660.3	661	22-02-2016
8	660	661.9	661	660	660.3	25-02-2016
9	660.4	661.1	661.9	660.1	660.9	03-03-2016
10	661.4	661	661.4	660	660.5	08-03-2016
11	661	661.1	661.3	660.3	660	17-03-2016
12	661.1	661.1	661.1	660.1	660.1	24-03-2016
13	662	660.2	661.9	660.1	660	30-03-2016
14	659	659	660	661.1	661	31-03-2016
15	660.3	660.5	660.3	661	661.2	03-04-2016
16	661.1	660	660.2	661.2	661.1	04-04-2016
17	663	660.4	660	661	661.2	06-04-2016

Figure3. SIGMA SIX - data interface (views) height of filter - SIX SIGMA before improvement

a. Drawing of average plate and the range of filter height: 660 mm, 2 ± mm: two parts

In Figure (4), the average and long plate of range is drawn by extracting the range and the average range to calculate the upper and lower limits of the range plate. The first plate represents the actual data according to the reality of the company and as recorded in their records, which shows it isn't controlled.

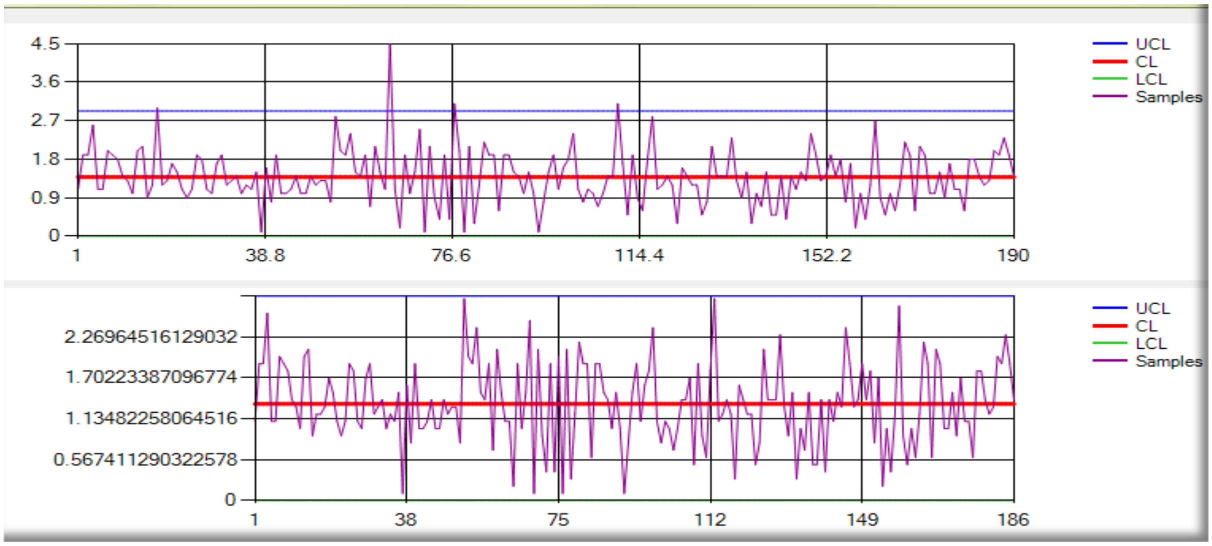


Figure4. Filter height range panel - before improvement

The reason of uncontrolled was the exit of four samples (17, 64, 77, and 110) as shown in Figure (5), therefore the out of limits samples were excluded and the painting was drawn again. The second plate was disciplined because the samples were inside the limits of control, so it was transferred to draw the average panel.

Round	Sample No.	X1	X2	X3	X4	X5	Range
1	17	663	660.4	660	661	661.2	3
1	64	661.6	659	661.1	657.1	660	4.5
1	77	660.8	663.9	661.9	661.1	661.1	3.10000000000002
1	110	658.4	660.5	661.5	660.4	661.1	3.10000000000002

Figure5. Samples out of limits of control in the filter height range panel - before improvement

After completing the drawing of the plate, the average plate (average-range) is calculated by extracting the average and range for each sample and then calculating the average range and average mean for the extraction of the upper and lower limits of the average plate. The first panel Figure 6, shows the actual reality of the average views taken from the actual reality of the company, which was uncontrolled because the samples were out of control limits (4-75-77-87-128-139-147-154).

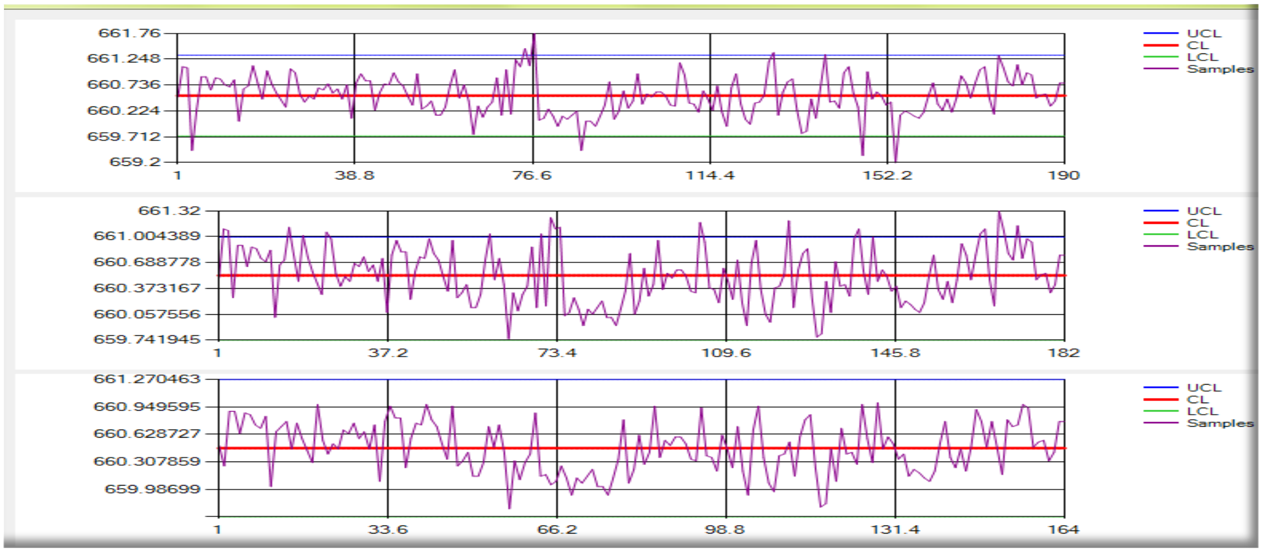


Figure 6. Average panel (average-range) Filter height - before improvement

So the samples that out of control limits were excluded and the paint was draw again, and the second painting is also not controlled due to the samples were out of limits (2-3-17-20-25-60-71-73-74-76-108-127-144-172-173-176 as shown in Fig. 7).

The third plate (the last plate of Fig. 7) was drawn after excluding the out of limits samples from the last plate showing that they were disciplined.

Round	Sample No.	X1	X2	X3	X4	X5	Average
1	4	660.3	659.1	657.7	660.1	660	659.44
1	75	661	661.1	661.3	662.9	661	661.46
1	77	660.8	663.9	661.9	661.1	661.1	661.76
1	87	659	658.5	659	660.3	660.4	659.44
1	128	661	661.4	661.2	661.5	661.8	661.38
1	139	661	661.7	661.2	661.4	661.4	661.34
1	147	660	659.1	659.2	659.9	658.5	659.34
1	154	659.5	659.9	658.5	659.1	659	659.2
2	2	660.8	661	661.8	660	661.9	661.1
2	3	660.2	661	662.1	660.9	661.2	661.08
2	17	663	660.4	660	661	661.2	661.12
2	20	661.3	662	660.3	661	660.5	661.02
2	25	660.1	661.2	660.9	661.1	662	661.06
2	60	661.4	661	661.1	661	660.7	661.04
2	71	661	661.1	661.1	661	661	661.04
2	73	661	661.9	661.1	661.1	661.1	661.24
2	74	661.4	661	661	661	661.1	661.1
2	76	661.4	661	661	661	661.2	661.12
2	108	660.9	661.1	661.5	660.5	661.9	661.18
2	127	661.2	661.5	661.2	661	661.1	661.2
2	144	661	661	661.4	661.1	661	661.1
2	172	661.9	661.8	661.3	660	660.2	661.04
2	173	661.2	661.2	661.6	660.6	660.9	661.1
2	176	661.9	661.2	661.2	661	661.3	661.32
2	177	661.9	661	660.2	661.1	661.2	661.08
2	180	660.9	661.1	661	661.2	661.5	661.14

Figure7. Samples excluded in average plate (average- range) Filter height - before improvement

In the final stage, the process rate was calculated at approximately 1.1, and as long as the last 1<, the range of areas is greater than the actual output of the process. The production process produces products within the characteristics of the specifications, which shows the level of third SIGMA was the current level of SIGMA for the company. Close to the upper limit of the characteristics of the process, it was found that the level of the third SIGMA was the level of the company, as shown in Figure (8):

Capability Process Ratio :	1.11111111111111
Capability Process Index :	0.849999999999985
The level of the company's sigma :	3.33333333333333

Figure8. Ratio, capability indicator and current level of SIGMA of the company, filter height - before improvement

B. Drawing average panel and standard deviation of the filter height: 660 mm, 2 ± mm: two parts

In Figure (10), the standard deviation plate (average - standard deviation) was calculated by calculating the standard deviation of each sample and then the average of the last for the extraction of the upper and lower limits of the deviation panel. It was found that the panel was not controlled from the first time of the drawing, due to the samples were out of control limits (64-77) so they were excluded and drawing the panel again. The second panel wasn't controlled due to the samples were out of control limits (110), therefore the sample out of limits was excluded and the panel was drawn for the third time (the final panel of Fig. 9) it was shown to be disciplined after excluding the uncontrolled samples shown in Figure (10), so it was transferred to drawing the average panel.

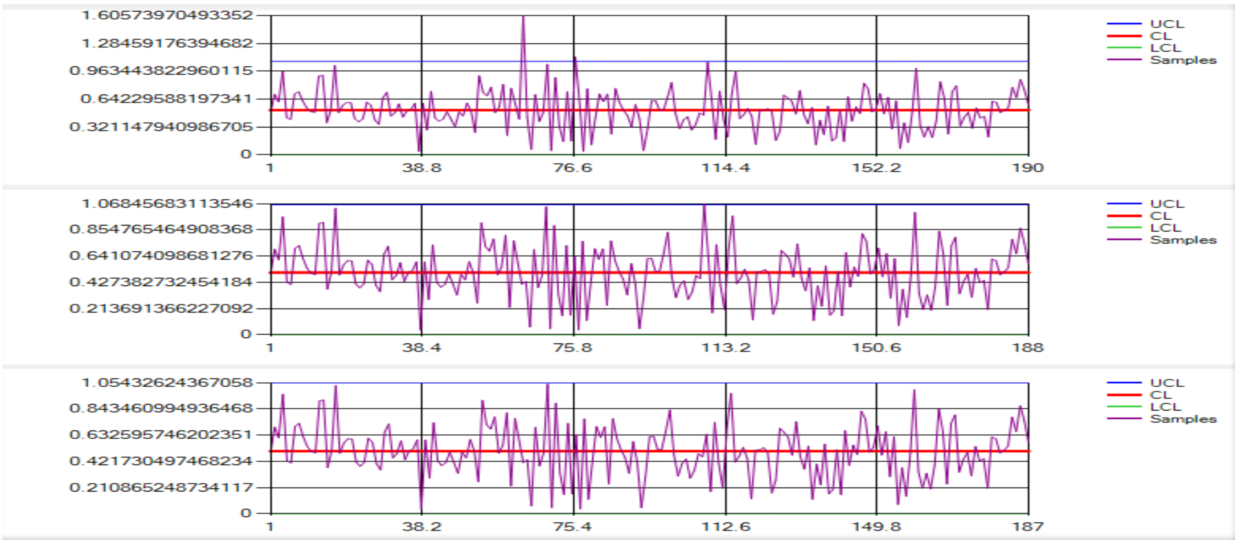


Figure9. Standard deviation panel of filter height - before improvement

Round	Sample No.	X1	X2	X3	X4	X5	Standard Deviation
1	64	661.6	659	661.1	657.1	660	1.60573970493353
1	77	660.8	663.9	661.9	661.1	661.1	1.1306635220082
2	110	658.4	660.5	661.5	660.4	661.1	1.06845683113546

Figure10. Samples excluded of the standard deviation panel for filter height - before improvement

In Figure (11), the average plate (Average - standard deviation) was drawn by calculating the average for each sample and the deviation for each sample and then calculating the average mean and the average deviation for the extraction of the upper and lower limits of the average plate, Figure (12) shows that the first plate is not controlled due to the exit of samples (4-75-77-87-128-147-154) from the control limits, so the samples were excluded and the drawing again, and the second plate is disciplined, so The estimated ratio of 1.12 and the estimated index of 0.82 was calculated and the company's current level of Sigma was calculated, which was the third level of Sigma.

Round	Sample No.	X1	X2	X3	X4	X5	Average	Sigma
1	4	660.3	659.1	657.7	660.1	660	659.44	0.962496753241254
1	75	661	661.1	661.3	662.9	661	661.46	0.728285658241316
1	77	660.8	663.9	661.9	661.1	661.1	661.76	1.1306635220082
1	87	659	658.5	659	660.3	660.4	659.44	0.76576758876305
1	128	661	661.4	661.2	661.5	661.8	661.38	0.27129319932499
1	147	660	659.1	659.2	659.9	658.5	659.34	0.553534100123913
1	154	659.5	659.9	658.5	659.1	659	659.2	0.473286382647962

Figure11. Samples excluded for average plate (average-standard deviation) Filter height - before Improvement

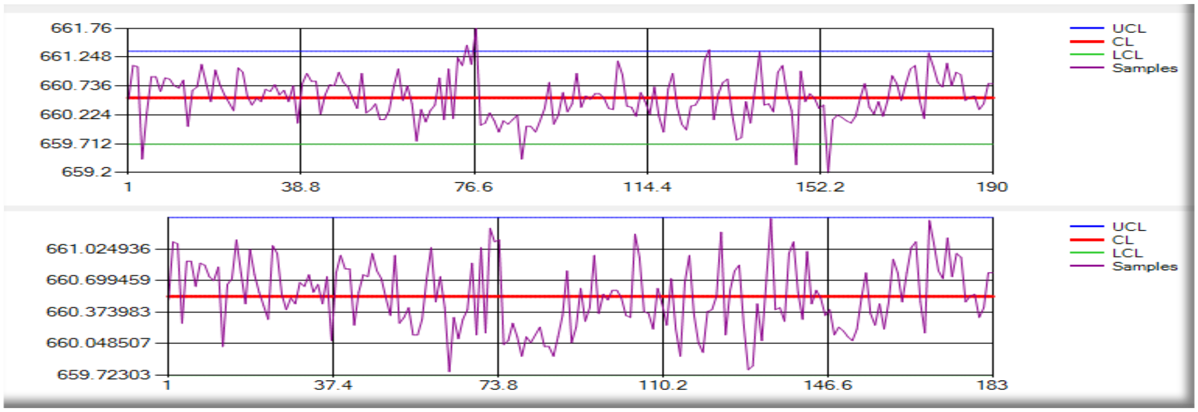


Figure12. Average plate (average - standard deviation) for filter height - before Improvement

3.1. DPMO is calculated by equations (1) (2), (3), (4), (5) referred to in Table (2).

3.1.1Belts clips: Two Parts

Figure 14 shows that the percentage of defects in the Belts clips of the filter is equal to 39.53252%, while the accuracy of the manufacturing processes is 60.46748%, the defect per unit produced is 38.87195% and the defect per opportunity is 0.1976626. The defects for each opportunity are equal to 197662.6, which mean that The Company's Sigma is the third level.

3.1.2. Third Stage: Analysis

This Stage involves identifying potential causes of variances and defects. The Ishikawa Scheme was used to determine the root causes of problems arising from differences in process and product defects.

3.1.3. Belts clips: Two Parts

During the repeated interviews with the plant inspection representative, the main and potential causes of poor quality and faults were identified. The main cause of defects in the Belts clips of working individuals, lack of experience and skill and lack of training programs were the main causes of the last main reason. The corrosion of cutting blocks and the non-maintenance of cutting equipment were the main reasons for the second reason the tools and equipment, The third main reason is represented by raw materials and semi-finished parts. The secondary causes were poor storage.

3.1.4. Fourth Stage: Improvement

For the purpose of improving the results obtained from the measurement phase, a number of suggestions and recommendations were put forward to the company and to take the necessary measures for improvement, including:

3. Train and motivate employees to improve the work method and develop them and raise their achievement rates to improve the efficiency of the completion of business

4. Review the procedures used in the inspection stations by the quality control department and take the procedures, and the development of the means of examination through the use of specialized equipment and new devices and not just theoretical examination

5 - Pay attention to the tools of modern quality improvement and quality control at the source and work to apply in all stages of manufacturing to improve processes and avoid the emergence of defects

6. Using Pareto charts to diagnose data on operational problems at all stages

7. Use Ishikawa's chart to analyze the problems that occur at each stage and identify the real causes

3.1.5. Fifth Stage: Controlling

In order to ensure that the process of improvement is effectively carried out in the company in question, a set of data was taken from the company's records after the process of improvement and tested by extracting the estimated production process and its capacity. Pareto charts were redrawn for all parts, it was found that the number of defect types and the number of defects decreased and consequently the number of defective producing units decreased; i.e. a decrease in defects per million chances and hence a high level of Sigma for the company. 20 research samples were submitted from 03-01-2018 to 30-01-2018 (obtained from the factory records) after giving suggestions for improvement, minimizing operational defects and problems, and redrawing the medium-range and medium-standard deviation boards, and recalculate the ratio of the operation's ability, the last indicator and the calculation of the company's Sigma level.

It is possible to observe, through Table (4), that the number of defects has decreased from 498 to 26 in the first defect, the accuracy of the weld, decreased in the second from 280 to 13, and thus the total defects are reduced and became 39 after being equal to 778, i.e. the DMAIC methodology has Actually reduced the overall defects in the production units. In other words, the costs resulting from the sales returns were reduced and the cost of re-examination, design, manufacturing, labor costs, materials, etc. was reduced.

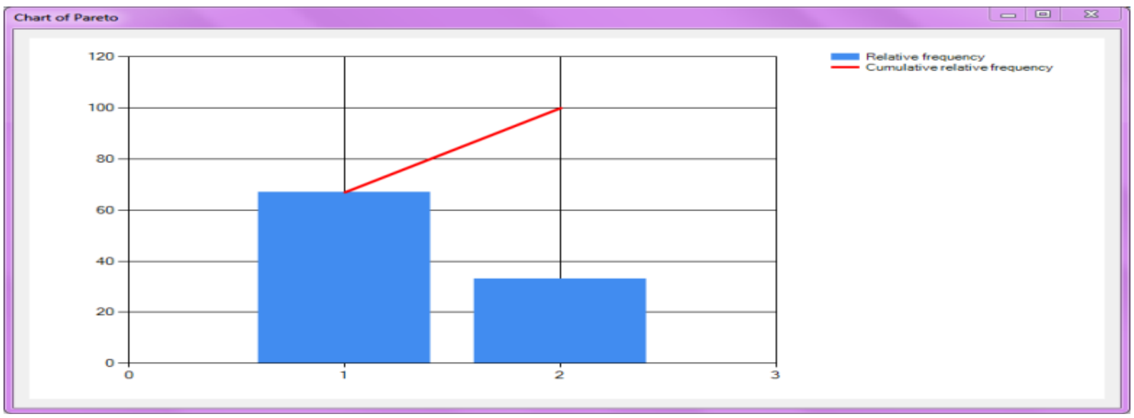
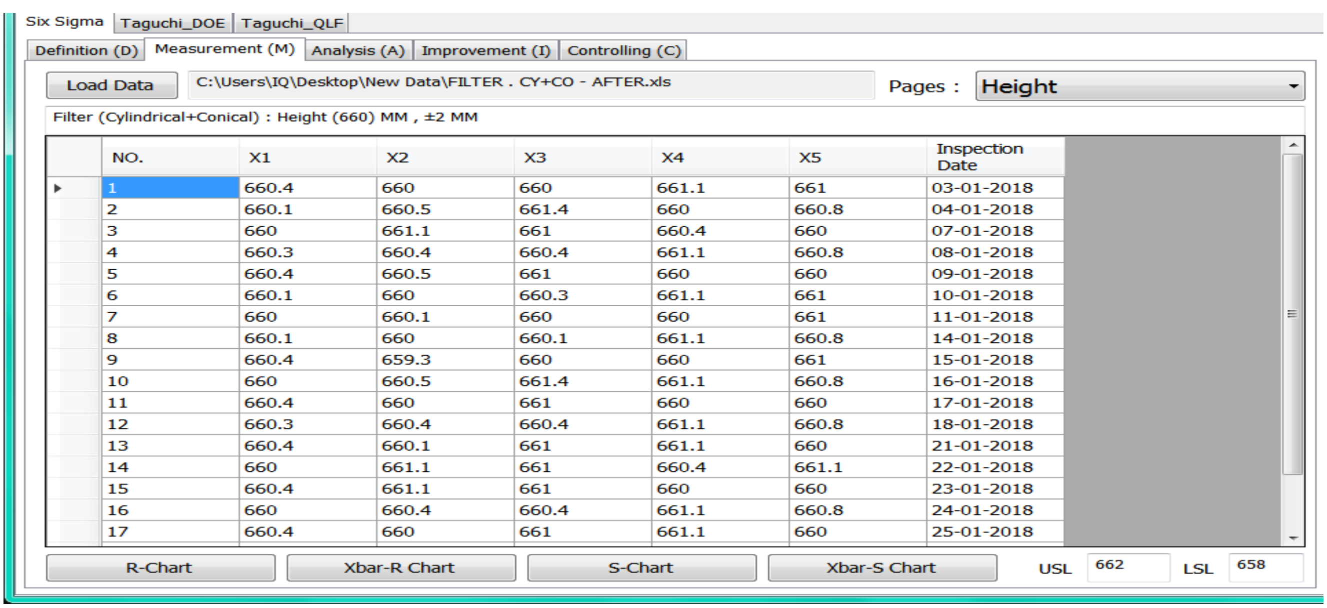


Figure13. Pareto Belts clips - after Improvement

Height of filter: 660 mm, ±2 mm: two parts



NO.	X1	X2	X3	X4	X5	Inspection Date
1	660.4	660	660	661.1	661	03-01-2018
2	660.1	660.5	661.4	660	660.8	04-01-2018
3	660	661.1	661	660.4	660	07-01-2018
4	660.3	660.4	660.4	661.1	660.8	08-01-2018
5	660.4	660.5	661	660	660	09-01-2018
6	660.1	660	660.3	661.1	661	10-01-2018
7	660	660.1	660	660	661	11-01-2018
8	660.1	660	660.1	661.1	660.8	14-01-2018
9	660.4	659.3	660	660	661	15-01-2018
10	660	660.5	661.4	661.1	660.8	16-01-2018
11	660.4	660	661	660	660	17-01-2018
12	660.3	660.4	660.4	661.1	660.8	18-01-2018
13	660.4	660.1	661	661.1	660	21-01-2018
14	660	661.1	661	660.4	661.1	22-01-2018
15	660.4	661.1	661	660	660	23-01-2018
16	660	660.4	660.4	661.1	660.8	24-01-2018
17	660.4	660	661	661.1	660	25-01-2018

Figure14. Filter height views - after Improvement

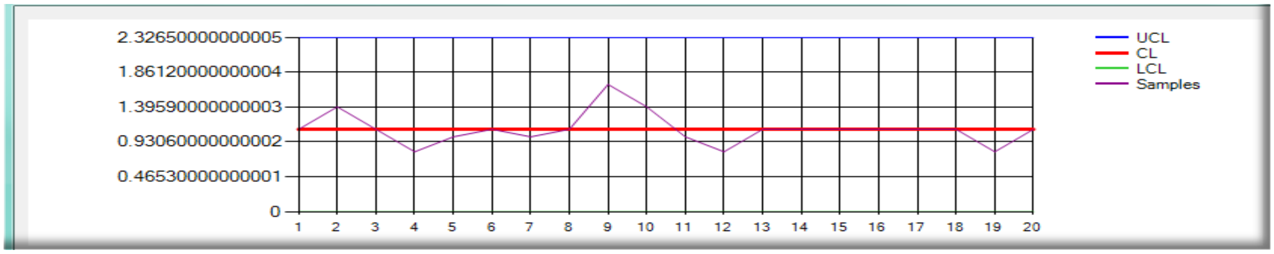


Figure15. Range plate after Improvement process - the height of the filter

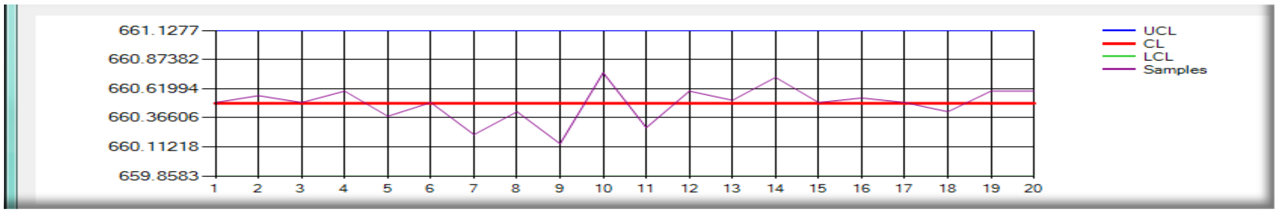


Figure16. Medium plate (medium - range) after Improvement - the height of the filter

In Figures. (15) (16), the plates of medium and range are statistically determined from the first time

Capability Process Ratio :	1.41843971631206
Capability Process Index :	1.0709219858156
The level of the company's sigma :	4.25531914893617

Figure17. The rate of the operation capacity and its index and the level of the company's Sigma after improvement - the height of the filter

figure (17) shows that the process capacity is 1.4% after it was1.1%, which means that the process is producing products that fall within the permissible limits, i.e. the range of outputs is smaller than the specified range and it is smaller than before, before improvement. The estimate has become almost 1% which is a good indicator of the process so that the output is closer to the higher end of the process properties, after it was approximately 8%; Therefore, the level of the company's scam has risen to become the fourth level after it was previously in the third level of sigma, which means that if the company continues to improve the levels will increase the sigma and thus improve processes and outputs, that is reducing the defects of products and reduce the cost of re-examination and analysis of problems and defects Or even avoid re-design processes, reducing the losses in time, effort and cost as a whole.

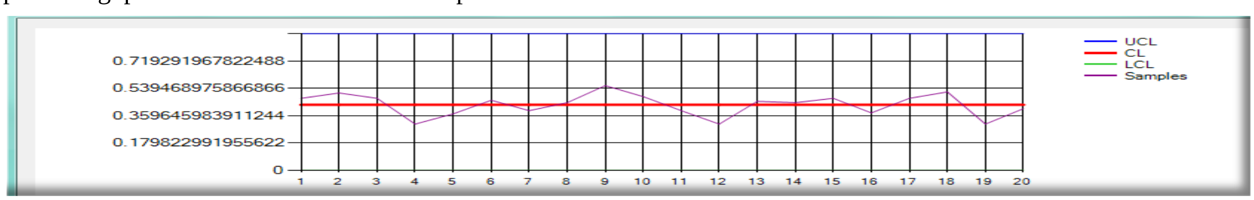


Figure18. Standard deviation plate after Improvement - filter height

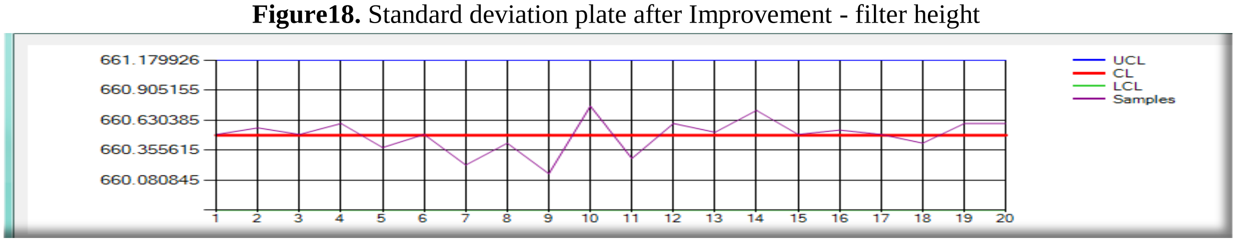


Figure19. Average plate (average - standard deviation) after Improvement - filter height

In Figure (19) it is possible to observe that the percentage of defects is approximately 4.6% after it was approximately 39%, while the accuracy of the operations is approximately 95% after it was approximately 60%, and the defects per unit produced is equal to about 38% to about 3% per unit, and the defects for each opportunity became almost 2.3 after it was 19.7%, and the defects per million chances were about 197 thousand and became about 23 thousand, which means that the company's level of Sigma after the improvements became the fourth level after the third level , That is, advanced levels can be achieved by reducing defects and improving the accuracy of operations Improvements have gone through, leading to customer satisfaction and high standards, so the improvement process is clear.

3.2. Application of the Taguchi function (Design of Experiments DOE) in the manufacturing line / air filter plant - Al-Zawraa General Company

Filter height: In Figure 19, filter (cylindrical + conical): Height (660) mm and permissible limits 2 mm increase or decrease. The worker's level, the worker's code, the worker's description, the first level, the second level. The skill of the worker was determined as the first factor and the radius of the cutting stone as a second factor. Then the first and second levels of the first and second factors were determined by a high low, 4 cm 5 cm respectively. The matrix of experiments was determined using MinitabL4, Factors: 2Runs: 4, L4 (2 ^ 2). It is worth mentioning that the specific factors and the specific levels can be L4, L8, L12, L16 or L32, but since the design Experiments took the lowest number of global experiments, so L4 was adopted. The experiment number, factor A, factor B, first viewing, second viewing, third viewing, fourth viewing, fifth viewing and the date of the examination.

In Figure (19) the results of the average calculation for each sample, and the average sample views at each level as shown below:

$$\bar{\bar{X}}_{k_i} = \frac{\sum_{i=1}^{k} \bar{X}_{k_i}}{n}$$

Where:i: the sequence number of the factor according to level, $\bar{X}$: the average, k: the influencing factor, n: the number of samples

The average of sample views averages (General Average) were then extracted at the levels as a whole and as shown in the equation below:

$$\bar{T} = \bar{\bar{X}}_k = \frac{\bar{\bar{X}}_{k_1} + \bar{\bar{X}}_{k_2} + \dots \bar{\bar{X}}_{k_n}}{N}$$

N: The average number of factor averages, equal to the number of levels.

The signal / noise ratio was then calculated after the standard deviation was calculated for each sample, and the average signal / noise for each factor was then calculated in each level by the equation below:

$$\overline{S/N}_{k_i} = \frac{\sum_{i=1}^{k} S/N_{k_i}}{n}$$

The average of signal / noise averages (General Average for signal / noise) for sample views, for each factor and for the levels as a whole was then extracted by the equation below:

$$\bar{T}_{S/N} = \overline{\overline{S/N}}_k = \frac{\overline{S/N}_{k_1} + \overline{S/N}_{k_2} \dots + \overline{S/N}_{k_n}}{N}$$

The relationship between the average effect of the factor and the general average was estimated by subtracting the last of the average of the values and at each level by the equation below:

$$E_{k_i} = \bar{\bar{X}}_{k_i} - \bar{T}$$

As well as for the average of signal / noise, through the equation:

$$E_{S/N_{k_i}} = \overline{S/N}_{k_i} - \bar{T}_{S/N}$$

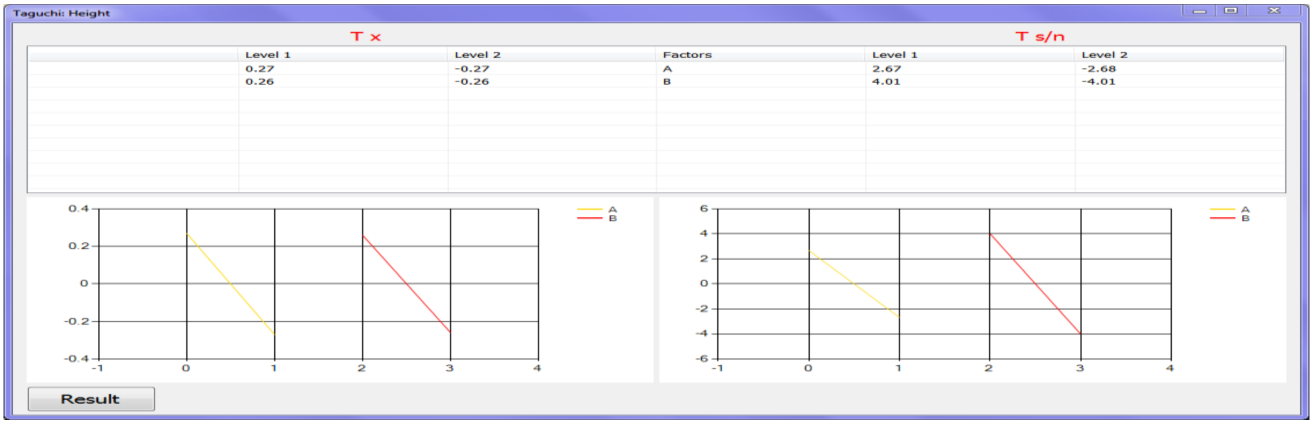


Figure20. Signal / Noise and Average Boards - Filter Height

In Figure (20), the boards were drawn for each factor according to the levels, by averages of the pre-extracted averages of the effect of the relation between the average mean and the general average of the last, and between the average signal / noise and the general average of the last, The levels of factors in the x-axis and the influence of the signal / noise represented by the Y-axis in terms of the signal board / noise, while the other board represents the factor levels of the X-axis, the Y axis represents the effects on the averages of measured values.

In Figure (21), the main effects of the factors of the resulting signal / noise ratio (shown in the figure above) were calculated to estimate the theoretical ratio of the signal / noise ratio to the optimal order of global levels by taking only the large positive values for each factor at any level (Figure 26), as shown in the equation in Figure (21). Therefore, estimates of the main effects of the mean of the factors were calculated to calculate the general mean of the factor averages by taking only the small positive values for each factor and at any level.

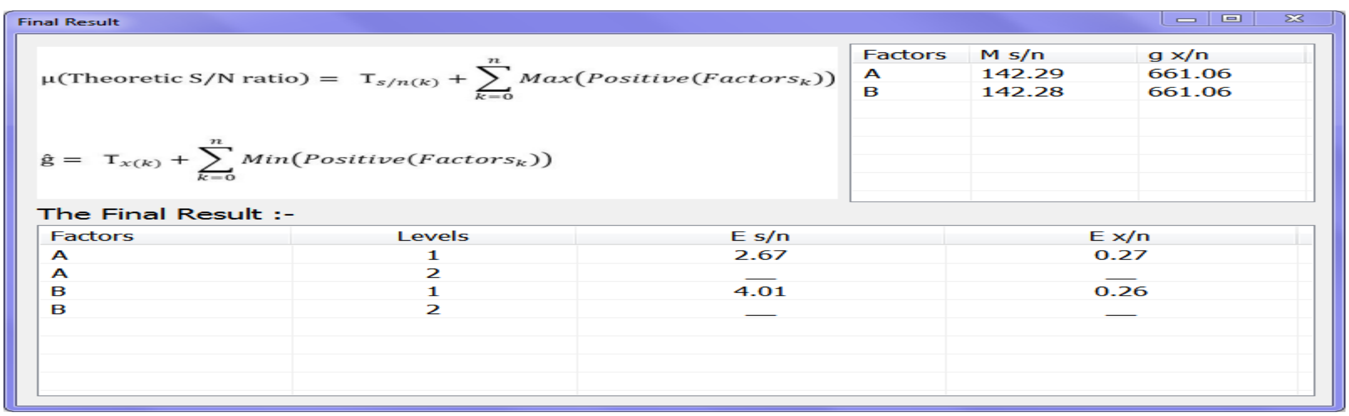


Figure21. Final results - filter height

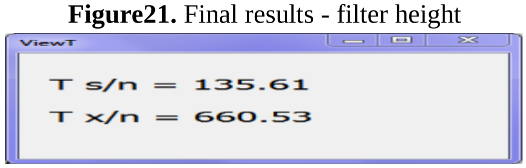


Figure22. Target values for average and signal / noise - filter height

Although the theoretical height of the air filter indicates that EA1EB1 is the order to be worked, it does not optimize for the height of the filter since the value of ĝ = 661.06 mm, that is a value that exceeds the allowable limits. Therefore, you must choose another order of the influencing factors in order to choose the order that minimizes the variances and achieve the value closer to the value required for the height of the filter, so EA2EB2 is the order to be worked is the ideal arrangement that it achieves the required filter height at the target value of mm660 as shown below:

ĝ = 660.53 – 0.27 – 0.26

= 660 mm

It achieves the lowest effect of the factors affecting the height of the filter (noise) as it achieves a signal / noise ratio equal to 128.92 db, which is less than the previous value which was equal to 142.29 db:

m (S/N) R = 135.61 – 2.68 – 4.01

= 128.92 db

4. Conclusion and Discussion

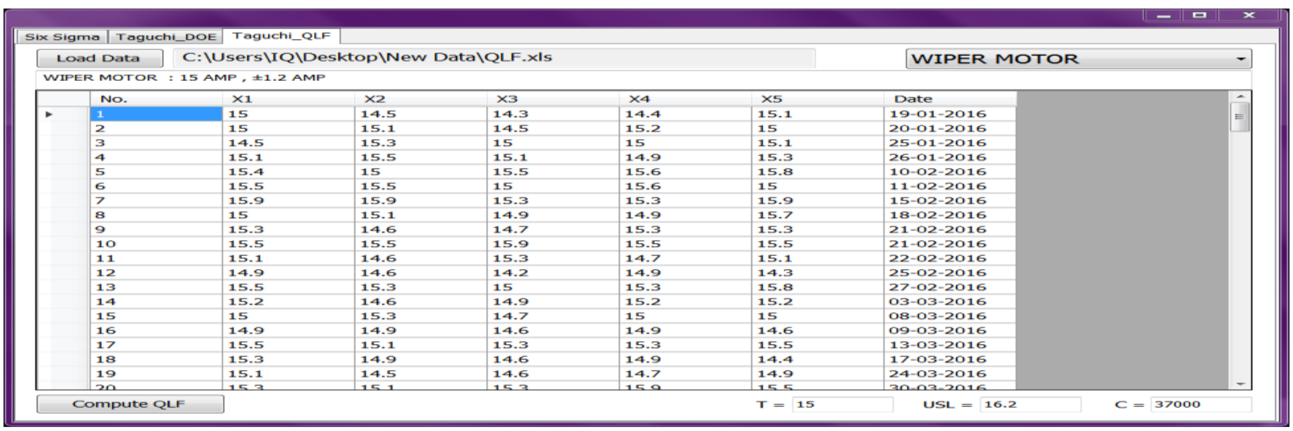
SCM quality of the company which directly affects the production process and company efficacy is considered in this research and following remarks concluded:

First: Six Sigma applications (DMAIC model) in the assembly line / General Company for the automotive industry: The same steps used in the filters product were used

Second: Application of the Taguchi function (Quality Loss Function (QLF)) in the assembly line / General Company for the automotive industry

The Taguchi loss function was used in the assembly line instead of experiment design because there were no variables and levels to study because the company was committed to its general plan, and the lack of alternatives for manufacturing parts.

Windshield Wipers Motor: 15 amps, ± 1.2 amps: Figure 29: The front view of the Windshield Wipers Motor: 15 amps, ± 1.2 amps, the target value (T) 15, the upper limit (USL) 16.2, and the cost of loss (C) 37000 dinars.



No.	X1	X2	X3	X4	X5	Date
1	15	14.5	14.3	14.4	15.1	19-01-2016
2	15	15.1	14.5	15.2	15	20-01-2016
3	14.5	15.3	15	15	15.1	25-01-2016
4	15.1	15.5	15.1	14.9	15.3	26-01-2016
5	15.4	15	15.5	15.6	15.8	10-02-2016
6	15.5	15.5	15	15.6	15	11-02-2016
7	15.9	15.9	15.3	15.3	15.9	15-02-2016
8	15	15.1	14.9	14.9	15.7	18-02-2016
9	15.3	14.6	14.7	15.3	15.3	21-02-2016
10	15.5	15.5	15.9	15.5	15.5	21-02-2016
11	15.1	14.6	15.3	14.7	15.1	22-02-2016
12	14.9	14.6	14.2	14.9	14.3	25-02-2016
13	15.5	15.3	15	15.3	15.8	27-02-2016
14	15.2	14.6	14.9	15.2	15.2	03-03-2016
15	15	15.3	14.7	15	15	08-03-2016
16	14.9	14.9	14.6	14.9	14.6	09-03-2016
17	15.5	15.1	15.3	15.3	15.5	13-03-2016
18	15.3	14.9	14.6	14.9	14.4	17-03-2016
19	15.1	14.5	14.6	14.7	14.9	24-03-2016
20	15.3	15.1	15.3	15.9	15.5	30-03-2016

Figure23. Front view of the Windshield wipers Motor - Taguchi

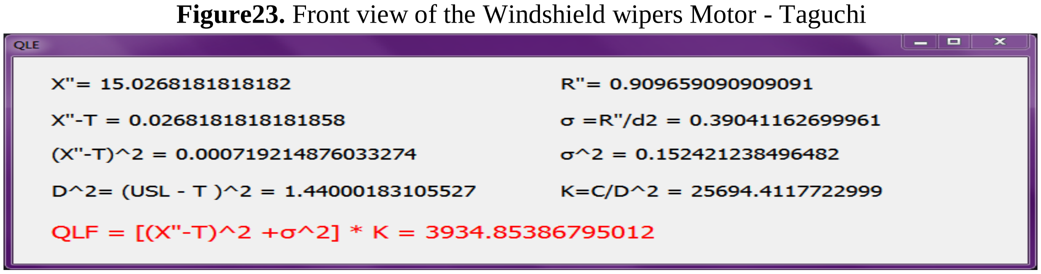


Figure 24. Quality loss function - Windshield wipers Motor

1 3520 *2 15495.984 = 54545863.68 Dinars

If compared to revenues for the actual production volume, it will represent the percentage of:

54545863.68 / 36960000000 = 0.14% of sales volume

In witness whereof, it is possible to observe losses due to deviations from the specifications set which the company must overcome by taking a set of procedures that reduce the percentage of defects and deviations and try to reach zero defects. Therefore, a reduction rate of 10% was proposed to indicate the savings that the company will achieve. , As shown in Table 6:

Table4. Proposed 10% reduction of deviations in the company

Discount rate 10%					
The research topic	QLF Current	σ^2Proposed	QLF Proposed	Estimated cost savings	**Annual savings of assumed production volume**
Master Scanners	3934.8538	0.1372	3543.2593	393.4853	**1676247.719**
Box lamp	273.9345	0.0657	248.2030	27.3934	**116696.097**
Lighter	728.9623	0.3065	656.9777	72.8962	**310537.812**
Central lock	8007.9009	0.0387	7877.9066	800.7900	**3411365.4**
Fog lamp	2550.3353	0.0504	2506.3720	255.0335	**1086442.71**

Therefore, the total annual savings that would be achieved if the company followed the reduction procedures by 10% would be equal to 6601289.738 dinars annually

In this section, Six Sigma and the Taguchi function were also used, but this time in the assembly line (in the General Company for automotive industry - Saiba (Tiba) car assembly). Here we would like to clarify the following:

1. Six Sigma worked very efficiently in the assembly line as it significantly reduced the number of defects and types, as explained in advance in the application stages, which in turn led to the upgrading of the company's level of Sigma from level 3 to 4, which was reached in the manufacturing line also, Which indicates the effectiveness of Six Sigma in both lines of research topic.

2. As for Taguchi, it was not possible to apply the design of the experiments (DOE) in the assembly line because of the lack of application requirements in this line. Therefore, we have to resort to the QLF application, which shows that the proposed QLF is less than QLF at the current 10% reduction rate as it became 91.5945 in the motor of wipers. This means that whenever the company seeks to reduce the percentage of deviations from the specifications, it will be able to achieve significant savings, such as achieved at the reduction of deviations by 10%, which amounted to 6601289.738 dinars.

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